Biology Genetics Worksheet

NAME ______________________

Terminology:

1. Gene:
2. Allele:
3. Locus:
4. Genotype:
5. Phenotype:
6. Homozygous:
7. Heterozygous:
8. True Breeding:
9. Test Cross:
10. F_1 Generation:
11. F_2 Generation:
12. Monohybrid Cross:
13. Dihybrid Cross:
14. Linkage
    - Incomplete:
    - Complete:
15. Incomplete Dominance:
16. Codominance:
17. Multiple Allele Inheritance:
18. Polygenic Inheritance:

19. Pleitropy:

20. Epistasis:

21. Law of Segregation:

22. Law of Independent Assortment:

23. Penetrance:

<u>Monohybrid Crosses</u>: examining a single trait in a cross between two individuals.

- This is how Mendel developed his **law of segregation**.
- From a series of monohybrid crosses, Mendel concluded that **an individual has two alleles for each trait, and those alleles "segregate" into separate gametes during gamete formation (meiosis)**.
- As a result, gametes carry one allele for each trait. In other words, the **gametes are haploid** (one allele for each trait), but when fused with another gamete during fertilization, the resulting **zygote is diploid** (two alleles for each trait).
- In a monohybrid cross with one individual true breeding for the dominant trait and the other true breeding for the recessive trait, the following phenotypic and genotypic ratios will be observed in the F_1 and F_2 generations:

P (parent generation):	TT	x	tt	
	Tall		Short	

F1:	**Genotypic Ratio**	100% Tt
	Phenotypic Ratio	100% Tall
F2:	**Genotypic Ratio**	1 TT : 2 Tt : 1 tt
	Phenotypic Ratio	3 Tall : 1 Short

1. List the possible gametes produced by an individual with each of the following genotypes:

TT ______ ______ ______ ______

Tt ______ ______ ______ ______

tt ______ ______ ______ ______

<u>Dihybrid Crosses</u>: examining two separate traits at a time in a cross between two individuals.

- This is how Mendel developed his **law of independent assortment**.
- From a series of dihybrid crosses, Mendel concluded that **alleles of different traits "assort" themselves independently of one another during gamete formation (meiosis)**.
- As long as the genes of the different traits are on different chromosomes (no linkage), each allele for each trait has an equal probability of ending up in a gamete with each allele of the second trait.
- This is true for any number of traits examined, provided the genes are not linked on the same chromosome.
- In a dihybrid cross with two individuals, one true breeding for the dominant trait and the other true breeding for the recessive trait, the following phenotypic and genotypic ratios will be observed in the F_1 and F_2 generations:

P (parent generation):	TTGG	x	ttgg
	Tall/Green		Short/Yellow

F1:	**Genotypic Ratio**	100% TtGg	
	Phenotypic Ratio	100% Tall Green	
F2:	**Phenotypic Ratio**	9 Tall/Green	(T_G_)
		3 Tall/Yellow	(T_gg)
		3 Short/Green	(ttG_)
		1Short/Yellow	(ttgg)

1. List the possible gametes produced by an individual with each of the following genotypes:

TtGg ______ ______ ______ ______

TtGG ______ ______ ______ ______

ttGg ______ ______ ______ ______

ttgg ______ ______ ______ ______

TtGgRr ______ ______ ______ ______ ______ ______ ______ ______

2. Given the following two loci, complete the Punnet square, provided below, for a mating between two individuals who are heterozygous for both traits. Fill in the table in part b) indicating the frequencies of each phenotype. (Capital letters denote dominant alleles)

SCALE COLOR: G = green g = orange

FIN COLOR: Y = yellow y = blue

Genotypes of parents: ________________ x _________________

a) complete the Punnet square

Female Gametes → Male Gametes ↓				

b) Indicate the expected phenotypic ratios from this mating:

PHENOTYPE	FREQUENCY or RATIO

3. Use a Punnet square to determine the phenotypic ratio of the offspring of the following dihybrid cross. (T = tall and t = short; R = round and r = wrinkled)

TtRr	x	Ttrr
Tall/Round		Tall/Wrinkled

Test Crosses: An individual with the dominant phenotype may have one of two genotypes: homozygous dominant or heterozygous. If the genotype of the individual is unknown, that individual is crossed with an individual known to be true breeding for the recessive phenotype (ie., homozygous recessive) and the phenotypic ratio of the offspring are used to determine the unknown genotype.

1. A tall individual of unknown genotype (T_) is mated with a short individual (tt) in a test cross.

    a) If the phenotypic ratio of the offspring is 100% tall, what is the genotype of the tall parent?

    ____

    b) If the phenotypic ratio of the offspring is 1 tall : 1 short, what is the genotype of the tall parent?

    ____

2. A tall/green (T_G_) individual is bred with a short/yellow (ttgg) individual in a test cross, and the phenotypic ratio of the offspring is 1 tall/green : 1 tall/yellow. What is the genotype of the tall/green (T_G_) parent?

    ____

NOMENDELIAN GENETICS: Many traits do not behave in a Mendelian way at all. In other words, not all genes function under the rules of simple dominance and recessiveness.

Incomplete Dominance: Instead of one allele being dominant to the other and completely masking the expression of the recessive allele, there are situations **where the heterozygote results in an intermediate phenotype between the dominant and recessive phenotypes**. This is generally the result of the protein product of the dominant allele not being expressed as completely as it is in the homozygote.

The color of many flowers is determined by a single gene, where the dominant allele R codes for the production of red pigment, and the recessive allele codes for the production of no pigmentation (white flowers). Heterozygotes (Rr) then are pink.

1. A pure breeding red snapdragon is crossed with a pure breeding white snapdragon. Construct the Punnet squares indicating the genotypic and phenotypic results of this cross, both the F_1 generation and the F_2 generation. Compare the results to that of a monohybrid cross of a trait that shows simple dominance and recessiveness.

Codominance: Instead of one allele being dominant to the other and completely masking the expression of the recessive allele, there are situations **where the heterozygote results in the phenotype of both alleles being expressed**. This is found in the human ABO blood type system. Below are the possible genotypes and phenotypes:

Genotype	Phenotype	Explanation
I^AI^A	A blood type	A antigens produced
I^AI^B	AB blood type	A and B antigens produced
I^AI^O	A blood type	A antigens produced but fewer than I^AI^A
I^BI^B	B blood type	B antigens produced
I^BI^O	B blood type	B antigens produced but fewer than I^BI^B
I^OI^O	O blood type	No antigens are produced

1. Do the following cross: I^AI^O x I^BI^O
A blood type B Blood Type

What are the genotypic and phenotypic ratios of this cross?

Multiple Alleles: Many genes have more than two alleles. The ABO blood type is also an example of a multiple allele system. Understand though that while there may be 3 or more alleles for the trait, each individual still carries only two alleles for the trait.

1. An individual has the A blood type. What cross would you do to determine the genotype of this individual?

Polygenic Inheritance: The expression of some traits are controlled my two or more genes. In these instances, instead of observing discrete phenotypes (like tall and short, or green and yellow), the phenotypes expressed tend to be continuous; from very short to very tall and everything in between, or white to black and everything in between (like human skin color).

Pleitropy: This is where a single gene has multiple effects on the phenotype of an individual. In Siamese cats, there is a single gene that determines the eye color, eye position (crossed-eyes), hearing and coat color of the cat.

Epistasis: This is where one gene controls the expression of another. For instance, there are situations where a gene codes for the production of a specific pigment (pigments are proteins). The epistatic gene is a separate gene, and the genotype of an individual for this gene determines whether the pigment will be produced or not.

1. A farmer is attempting to raise a flock of pure brown chickens. Feather color is controlled by two genes, one is epistatic. The genes and alleles are as follows:

Color Gene	Epistatic Gene	
B = brown	E =	inhibits production of pigment
b = gray	e =	no effect

- An individual who is EE or Ee is white.

a) Construct a Punnet square showing the possible F_1 offspring for these two parents: BBEe and Bbee.

b) What is the phenotypic ratio of the offspring from this cross?

A COUPLE MORE QUESTIONS:

1. A man with group A blood marries a woman with group B blood. Their first child has group O blood.

    a) What are the genotypes of the mother, the father and the child?

    b) What other genotypes, and in what frequencies, would you expect in the children from this marriage? Show your work (Punnet square).

2. You conduct a cross between two individuals. One is homozygous recessive while the other is heterozygous for both traits. The two traits are: height, where T = tall and t = short, and color, where G = green and g = yellow.

    a) What do you predict the phenotypic frequencies of the offspring to be (assume complete dominance for both genes)?

    b) When you conduct the cross, you actually observe the following frequencies: 0.50 Tall/Green and 0.50 Short/Yellow. Propose a possible explanation for this situation. (Hint: what does Mendel's law of independent assortment state, and what must be true for this law to apply?)